

The Preventive Health Behaviors of Long-Term Survivors of Cancer and Hematopoietic Stem Cell Transplantation Compared with Matched Controls

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Little is known about the health promotion, prevention, and disease screening behaviors of cancer survivors treated with hematopoietic cell transplantation (HCT), who undergo arduous treatment and may be at particular risk for late effects and secondary malignancies. The purposes of this study were to examine the current health and secondary prevention behaviors of long-term HCT survivors compared with matched controls without cancer, and to identify sociodemographic and clinical factors associated with appropriate preventive practices. HCT survivors (n = 662) were drawn from 40 North American transplantation centers. Peer-nominated acquaintances of survivors matched on sex, age, education, and marital status served as controls (n = 158). Data were collected a mean of 6.7 years post-HCT (range, 1.8-22.6 years). Despite a greater frequency of physical exams, the HCT survivors had similar health and screening behaviors as the matched controls. Sociodemographic factors were associated with health prevention behaviors in expected ways. Some differences between disease group and type of transplant were found, with survivors of acute leukemia less likely to report regular exercise, autologous transplant survivors more likely than allogeneic transplant survivors to report screenings for breast and cervical cancer, and allogeneic transplant survivors more likely than autologous transplant survivors to report undergoing a skin exam in the previous year. Despite higher levels of engagement with health care providers, HCT survivors had similar health behaviors as matched controls and comparable to those reported by cancer survivors who did not undergo HCT. There remains considerable room for improvement. These findings support the need for further education of both HCT survivors and health practitioners.

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INTRODUCTION

By the year 2020, the number of cancer survivors in the United States is expected to increase to 18 million,

with 70% living 5 years or longer [1]. The rising number of cancer survivors means more individuals at increased risk for cancer recurrence, secondary cancers, and late effects of treatments [2]. Survivors of hematopoietic cell transplantation (HCT) are at particular risk for adverse outcomes because of the intensity of the conditioning regimen and complications of treatment (eg, graft-versus-host disease [GVHD]) [3,4]. Engaging in health promotion and disease prevention activities could attenuate some of the secondary health problems, as well as improve quality of life [5]. Although there is a growing literature on the health behaviors of cancer survivors, the prevalence of preventive health behaviors in HCT survivors is largely unknown.

Surviving the rigors of HCT treatment might motivate survivors to protect their health. For some, cancer/HCT may serve as a “wake-up call” that life is fragile and good health is not guaranteed, motivating them to stop smoking or begin exercising. For others, preventive health behaviors may be a way to maximize posttreatment rehabilitation, recovery, and quality of

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life, or as a way to exert control over one's body during a period in which little control is experienced. On the other hand, fear of recurrence, desire to avoid medical contact, or lack of financial resources or insurance coverage could reduce the frequency of preventive health practices.

Many cancer survivors do initiate exercise, diet, and other healthful lifestyle changes after diagnosis [6]. Certain behavior changes, such as quitting smoking and decreasing alcohol consumption, are more pronounced in survivors with cancers related to those behaviors, such as lung cancer and head and neck cancer [6]. Nonetheless, many cancer survivors continue to smoke, to remain overweight or obese [6,7], and/or to not engage in physical activity [7]. The health behavior patterns in cancer survivors and controls are often comparable [8,9]. The prevalence of cancer screening may be somewhat higher in cancer survivors than in those with no history of cancer [10], although rates vary considerably.

It is possible that along with differences based on cancer site, differences in treatment experience could affect subsequent health behaviors. Compared with conventional cancer treatments, the high-dose therapy associated with HCT involves greater intensity and higher risk, which could contribute to greater motivation on the part of HCT survivors to engage in healthy behaviors. Conversely, the intensity of the treatment could lead to greater physical or mental health impairments that could interfere with a survivor's ability or motivation to engage in some health behaviors, such as exercise. The survivor might feel so "lucky" to have survived that he or she becomes less vigilant for signs of a second cancer and other diseases. Nonetheless, most HCT survivors appear to have regular follow-up with physicians, often for many years [3], in contrast to adult survivors treated with conventional therapy, as many as 60% of whom report no regular medical follow-up [10]). This repeated contact of HCT survivors with health providers should increase the likelihood of regular screenings and opportunities for education about health behaviors.

This is the first study to compare the health behaviors and secondary cancer screening rates in long-term HCT survivors and matched acquaintance controls without cancer. The goals of this cross-sectional study were to (1) identify the prevalence of health behaviors, screening rates, and other health practices in very-long-term HCT cancer survivors compared with matched noncancer controls and (2) identify sociodemographic and clinical factors associated with those health behaviors. We hypothesized that HCT survivors would be more likely than matched controls to engage in healthy behaviors, cancer screenings, and good health practices given the intensity of their treatment and their "second chance at life." We also investigated for differences in behaviors based on cancer site, type

of transplant, time since transplantation, treatment intensity, and presence of GVHD.

METHODS

This report examines previously unpublished data from a large multisite study comparing long-term quality of life in cancer/HCT survivors and a subset of matched peer-nominated controls. Data on the quality of life of survivors compared with controls was presented previously, as were details regarding survivor characteristics, study procedures, and institutional review board approval obtained from each participant [11]. To be eligible for the study, a survivor had to have undergone single allogeneic or autologous HCT during adulthood for 1 of 4 diseases (acute leukemias, chronic myelogenous leukemia [CML], lymphoma, and breast cancer), to have undergone HCT at least 1 year previously, and to have been in continuous remission since the transplantation.

Survivors were randomly selected from a stratified list (by disease, type of transplant, time since transplantation, and intensity of pre-HCT treatment) of eligible survivors at 40 transplantation centers in North America registered with the Center for International Blood and Marrow Transplantation (CIBMTR). Because the BMT population is predominantly Caucasian, we oversampled African Americans, to increase the ethnic diversity of the sample. A total of 2447 potentially eligible survivors were identified from the CIBMTR; 1946 of these were selected at random for potential study enrollment. Of these, 262 had no available contact information and 295 were ineligible, most because of death or disease relapse. Attempts were made to reach the remaining survivors. Contact was made with 960; of these, 118 declined participation and 138 provided verbal consent but did not return a consent form. A potential participant who declined or was unable to be contacted was replaced by the next person on the randomized list. A total of 704 survivors (73.3% of the eligible survivors successfully contacted) provided written consent. Of these, 42 were withdrawn from the study for various reasons, including voluntary withdrawal, study ineligibility, or loss to follow-up. Of those who consented, 94% completed the study.

Controls were survivor acquaintances matched to survivors on sex, age, education, and marital status, with no history of cancer/HCT and no involvement in providing care to the survivor. Of the study-eligible matched acquaintances contacted, 90% participated in the study. Data were collected between March 2000 and September 2002.

Study Measures

Self-reported study measures assessed survivors' health and secondary prevention behaviors and other

health practices, physical functioning, and sociodemographic characteristics, including health insurance status. Data on disease and treatment factors and functional status were extracted from CIBMTR registry data. Participant groups completed identical measures. Half of the measures were completed by hand, and the other half were completed during computer-assisted telephone interviews. Medical records were not reviewed to confirm self-reports.

Preventive Health Behaviors

A 30-item questionnaire was designed for the study, based on recommended guidelines at the time. Respondents were asked whether they underwent any of the following procedures in the previous 12 months: physical exam, cholesterol check, stool check, sigmoidoscopy or colonoscopy, blood pressure, eye exam, dental exam, skin exam, and flu shot. Additional items for female respondents included clinical breast exam, mammogram, and pap smear, and those for male respondents included prostate digital rectal exam and prostate-specific antigen testing. Respondents also were asked how often they currently smoked cigarettes or a pipe or used chewing tobacco, drank more than 2 glasses of alcoholic beverages in a day, and exercised moderately for 20 minutes at least 3 times a week, with responses ranked on a Likert-type scale.

Sociodemographic Information

This information included age, race/ethnicity, marital and occupational status, level of education, and annual household income.

Disease and Treatment Information

This information included cancer diagnosis, previous cytotoxic treatment (less or more), and type of transplant (allogeneic or autologous).

Physical Functioning

The SF-36 physical functioning subscale of the SF-36 MOS¹² was used to measure current physical functioning.

Statistical Analyses

Survivors and controls were compared on age using a 2-sample *t*-test and on other categorical demographic characteristics using χ^2 tests. The χ^2 tests were used to compare the prevalence of health behaviors and screening in survivors and controls. Logistic regression models were used to adjust these comparisons for age, sex, and education. Within the survivor group, screening and health behaviors were compared between groups defined by sex, age, education, cancer type, transplant type, and other demographic and clinical variables. Examination of health behaviors was a predefined exploratory aim of the project; no power

calculations were conducted for the exploratory endpoints. All tests were 2-sided, and no adjustments were made for multiple comparisons.

RESULTS

Details regarding participant identification and selection were published previously, including a flow chart summarizing recruitment of survivors [11]. In terms of demographic characteristics, compared with all nonparticipants (those lost to follow-up, unreachable, withdrawn from the study, passively declined, or actively declined), participants were older (median age, 42 vs 38 years; $P < .001$), female (62% vs 52%; $P < .001$), and Caucasian (83% vs 71%; $P < .001$). However, when participants were compared only with those who actively refused to participate, only demographic differences in race/ethnicity remained (83% of participants were Caucasian vs 68% of those who actively refused participation; $P < .001$).

In examining potential differences between participants and nonparticipants on clinical characteristics, we found the following. Compared with all nonparticipants (those lost to follow up, unreachable, withdrawn from study, or passively or actively declined), participants were less likely to have lymphoma (20% vs 28%), more likely to have breast cancer (23% vs 18%; $P < .001$), more likely to be in the early disease status before pre-HCT treatment (61% vs 48%; $P < .001$), more likely to have received an autologous transplant (58% vs 29%), and less likely to have received an allogeneic transplant (42% vs 71%; $P < .001$). When participants were compared only with those who actively refused participation, there were no differences in terms of disease group ($P = .12$) or disease status before HCT ($P = .14$). Participants were more likely than active refusers to have received an autologous transplant (58% vs 42%; $P = .001$).

Table 1 summarizes the demographic characteristics of survivors and controls. The 2 groups were similar, except that those in the survivor group were more likely to be single, to have a lower income, and be less educated. There were no differences between survivors and controls in terms of having health insurance/medical coverage and having a physician. Table 2 summarizes the clinical characteristics of the survivor group.

Reported Health Behaviors, Health Examinations, Cancer Screenings, and Influenza Vaccination Practices of Survivors Compared to Matched Controls

Table 3 gives the prevalence of reported health behaviors, health exams and cancer screenings, and influenza vaccination practices in the past year in survivors and controls. There was no difference in tobacco use between survivors and matched controls. Survivors

Table 1. Demographic Characteristics for Survivors (n = 662) and Matched Controls (n = 158) and Survivor Clinical Characteristics

	Survivors	Matched Controls
Age, years, median \pm SD, range	49.1 \pm 10.3, 21-77	50.1 \pm 14.2, 27-76
Male	38%	30%
Married or partnered*	73%	87%
Caucasian	92%	95%
Education		
\leq High school/GED	29%	19%
Some college/technical/AA	32%	32%
College degree or higher	39%	49%
Occupational status†		
Working or student	73%	75%
Not working	15%	5%
Retired	11%	20%
Annual family income‡		
< \$40,000	33%	18%
\$40,000-\$80,000	39%	47%
> \$80,000	28%	34%
Health insurance, % covered	96%	97%
Have a physician	98%	97%

Percentages shown represent the percentage of respondents with non-missing data for that variable. Some percentages may not add up to 100% because of rounding.

* $P < .001$.

† $P < .01$.

‡ $P < .05$.

were less likely than controls to engage in regular exercise and to report drinking alcohol (Table 3). No group differences on reports of engaging in all 3 healthy behaviors were found. Body mass index (BMI) was similar in the 2 groups.

Compared with controls, survivors were more likely to have had a physical exam ($P = .002$), a blood pressure check ($P = .02$), and a skin exam ($P = .01$), but less likely to have had a dental exam ($P = .0001$). Cancer screening behaviors were similar in the 2 groups,

Table 2. Clinical Characteristics of Survivors (n = 662)

Time since HCT, years	Mean, 7.0 \pm 3.1; median, 6.6; range, 1.8-22.6
Type of transplant, n (%)	
Allogeneic HCT	272 (41%)
Autologous HCT	390 (59%)
Malignant disease at initial diagnosis, n (%)	
Acute leukemia*	243 (37%)
Breast cancer	156 (24%)
Hodgkin/non-Hodgkin lymphoma	132 (20%)
CML	131 (20%)
Intensity of pre-HCT cytotoxic treatment, n (%)†	
Less intense	441 (67%)
More intense	221 (33%)
Allogeneic HCT survivors with cGVHD, n (%)	83 (40%)

HCT indicates hematopoietic cell transplantation; cGVHD, chronic graft-versus host disease; CML, chronic myelogenous leukemia.

Some percentages may not add up to 100% because of rounding.

*Includes acute myelogenous leukemia and acute lymphocytic leukemia.

†The *less intense* treatment group included patients undergoing HCT for chronic-phase CML within 1 year of diagnosis, for acute leukemia or lymphoma in first complete remission, and for adjuvant treatment of high-risk stage II or III breast cancer. The *more intense* treatment group included those undergoing HCT for chronic-phase CML > 1 year after diagnosis, for accelerated or blast-phase CML, for acute leukemia or lymphoma beyond first remission, and for metastatic breast cancer.

Table 3. Reported Health Promotion Behaviors, Examinations, Cancer Screenings, and Influenza Vaccination Practices of Survivors Compared to Matched Controls

	Survivors, n (%)	Matched Controls, n (%)	P Value
Health promotion behaviors			
How often do you smoke?			
Never	555 (87)	133 (85)	.547
Rarely, sometimes, often, always	82 (13)	23 (15)	
How often do you drink more than 2 alcoholic beverages per day?			
Never, rarely	542 (85)	117 (75)	.003
Sometimes, often, always	96 (15)	36 (25)	
How often do you exercise moderately for 20 minutes at least 3 times a week?			
Never, rarely, sometimes	407 (64)	86 (55)	.046
Often, always	231 (36)	70 (45)	
Engagement in all 3 health behaviors*			
No	461 (72)	105 (67)	.232
Yes	178 (28)	51 (33)	
Body mass index			
Underweight (BMI < 18.5)	19 (3)	3 (2)	.586
Normal (BMI = 18.5-24.9)	275 (45)	77 (51)	
Overweight (BMI = 25-29.9)	277 (45)	59 (39)	
Obese (BMI \geq 30)	45 (7)	12 (8)	
Examinations and cancer screenings in the last 12 months			
Physical exam			
Yes	582 (91.08)	123 (80.39)	.0018
No	57 (8.92)	30 (19.61)	
Blood pressure check			
Yes	614 (96.1)	138 (90.2)	.0189
No	25 (3.9)	15 (9.8)	
Dental exam			
Yes	491 (76.96)	139 (90.85)	.0001
No	147 (23.04)	14 (9.15)	
Skin exam			
Yes	302 (47.41)	55 (35.95)	.011
No	335 (52.59)	98 (64.05)	
Colorectal cancer screening (FOB, sigmoidoscopy, and/or colonoscopy, age 50+ only)			
Yes	143 (47.04)	43 (57.33)	.110
No	161 (52.96)	32 (42.67)	
Breast cancer screening (CBE and/or mammogram, women aged 50-65 years only)			
Yes	132 (76.74)	37 (84.09)	.292
No	40 (23.26)	7 (15.91)	
Pap smear (women only)			
Yes	292 (72.64)	90 (82.57)	.034
No	110 (27.37)	19 (17.43)	
Prostate cancer screening (digital rectal exam and/or prostate-specific antigen, men aged 50+ years only)			
Yes	72 (62.61)	20 (80.00)	.097
No	43 (37.39)	5 (20.00)	
All suggested screening (listed above) for age/sex			
Yes	105 (16.43)	31 (19.87)	.306
No	534 (83.57)	125 (80.13)	
Vaccinations in the last 12 months			
Influenza vaccination†			
Yes	381 (59.72)	50 (32.68)‡	< .001
No	257 (40.28)	103 (67.32)	

Numbers may not add up because of missing data.

*Defined as never smoking, never or rarely drinking alcohol, and often or always engaging in exercise.

†Because of varying physician preferences regarding immunizations in patients with active GVHD, the 83 survivors who reported having active GVHD were excluded.

‡73% of controls over the age of 65 years and 95% of survivors over the age of 65 years reported having received the influenza vaccine ($P = .072$).

except that survivors were less likely to have had a pap smear ($P = .034$). Survivors were more likely to have had the influenza vaccine than all controls

Table 4. Health Behaviors of Survivors by Sex, Age, and Educational Status

	Smoking, % (95% CI)	Drinking % (95% CI)	Exercising, % (95% CI)
Male	16.7 (12.1-22.1)	20.1 (15.2-25.8)	36.3 (30.2-42.8)
Female	10.7 (7.8-14.1)	12.1 (9.1-15.7)	36.1 (31.4-41.0)
P	.03	.007	.96
Age (years)			
20-39	15.91 (10.1-23.3)	15.2 (9.5-22.4)	34.9 (26.8-43.6)
40-59	13.47 (10.3-17.2)	15.92 (12.5-19.9)	35.3 (30.6-40.2)
> 60	6.73 (2.8-13.4)	11.54 (6.1-19.3)	41.4 (31.8-51.4)
P	.04	.48	.33
Education			
≤ High school/GED	17.11 (12.0-23.3)	14.9 (10.1-20.8)	85.11 (79.2-89.9)
Some college	12.44 (8.2-17.8)	16.9 (12.0-22.8)	83.08 (77.2-88.0)
≥ College degree	9.35 (6.0-13.7)	13.8 (9.8-18.8)	86.18 (81.2-90.2)
P	.02	.78	.0001

but less likely than controls over the age of 65 years (for whom the vaccine is recommended).

Sociodemographic Factors Associated with Survivor Health Behaviors

In bivariate analyses, survivors who were male, younger, and had less education were more likely to report smoking than survivors who were female, older, and more educated (Table 4). In both univariate and multivariate analyses, male survivors were more likely to report drinking than female survivors (males, odds ratio [OR] = 2.33; 95% confidence interval [CI] = 1.56-3.45; $P < .0001$). Survivors with more education were more likely to report exercising than those with less education, whereas sex and age made no difference.

In multivariate analyses, male sex, younger age, and less education were independently associated with smoking (males: OR = 1.56, 95% CI = 0.41-0.98, $P = .051$; younger age: OR = 0.74 per 10 years, 95% CI = 0.62-0.89, $P = .002$; those with less education: OR = 1.38 for high school/GED or less [95% CI = 0.83-2.28], OR = 0.61 for college degree or higher [95% CI = 0.36-1.04], $P = .01$). There were no group differences in tobacco or alcohol use (survivor vs control) after adjusting for sex, age, and education ($P = .31$ and $.057$, respectively). Age and education, as well as greater physical functioning, were related to physical activity levels; that is, the survivors who were more likely to engage in physical exercise were older (OR = 1.20 per 10 years; 95% CI = 1.03-1.40; $P < .02$), more educated (OR = 1.57 for college degree or higher, 95% CI = 1.10-2.23; OR = 0.82 for HS/GED or less, 95% CI = 0.55-1.23; $P = .001$), and reported greater physical functioning (score of > 85 on the SF 36 subscale: OR = 3.10; 95% CI = 2.24-4.27; $P < .0001$). The difference in reported exercise behavior among survivors and controls found in univariate analyses were no longer significant after adjusting for sex, age, education, and physical functioning ($P = .63$).

Thus, after adjusting for age, sex, and education (and physical functioning for exercise behaviors), the estimated prevalence of the health behaviors of survivors and controls were as follows: tobacco use, 12% versus 15% (95% CI = 10%-15% and 10%-23%, respectively); physical activity, 34% versus 32% (95% CI = 31%-38% and 25%-40%, respectively); alcohol use, 14% versus 25% (95% CI = 12%-17% and 19%-33%, respectively).

Disease and Treatment Factors Associated with Survivor Health Behaviors

No relationship was found between survivor-reported health behaviors (smoking, alcohol use, and exercise) and the number of years since HCT, amount of pre-HCT cytotoxic treatment (less vs more), or type of transplant (allogeneic vs autologous). Within the subset of allogeneic survivors, those with cGVHD were less likely to smoke ($P < .03$). Survivors of acute leukemia were less likely to report engaging in regular exercise compared with survivors of CML, lymphoma, and breast cancer ($P \leq .04$) and less likely to engage in all 3 health behaviors (smoking, alcohol use, and exercise) compared with all other groups ($P < .03$) (Table 5).

Disease and Treatment Factors Associated with Screening Practices of Survivors

Table 6 presents differences in reported cancer screening behaviors by disease group and type of transplantation. Autologous transplantation survivors were more likely than allogeneic transplantation survivors to report screenings for breast and cervical cancer, which was not solely accounted for by a breast cancer diagnosis. Allogeneic transplantation survivors were more likely to report having undergone a skin exam in the last year ($P = .004$).

With regard to the intensity of pretransplantation therapy, survivors who received less intensive therapy were more likely to report having had a physical exam in the last year ($P = .045$), but less likely to report

Table 5. Survivor Health Behaviors by Disease Group (n = 662)

	Acute Leukemia	CML	Lymphoma	Breast Cancer	P Value
How often do you smoke?					
Never	202 (86.3%)	107 (85.6%)	111 (86.0%)	135 (90.6%)	.545
Rarely...always	32 (13.7%)	18 (14.4%)	18 (14.0%)	14 (9.4%)	
How often do you drink more than 2 alcoholic beverages per day?					
Never, rarely	199 (85.0%)	106 (84.8%)	111 (86.0%)	126 (84.0%)	.972
Sometimes...always	35 (15.0%)	19 (15.2%)	18 (14.0%)	24 (16.0%)	
How often to you exercise moderately for 20 minutes at least 3 times a week?					
Often, always	68 (29.1%)	49 (39.2%)	51 (39.5%)	63 (42.0%)	.037†
Never...sometimes	166 (71.9%)	76 (60.8%)	78 (60.5%)	87 (58.0%)	
All 3 healthy behaviors?*					
Yes	50 (21.4%)	35 (27.8%)	43 (33.3%)	50 (33.3%)	.028‡
No	184 (78.6%)	91 (72.2%)	86 (66.7%)	100 (66.7%)	

*Defined as never smoking, never or rarely drinking alcohol, and often or always engaging in exercise.

†Pairwise comparisons: acute leukemias versus CML, $P = .051$; acute leukemias versus lymphoma, $P = .042$; acute leukemias versus breast cancer, $P = .009$.

‡Pairwise comparisons: acute leukemias versus CML, $P = .172$; acute leukemias versus lymphoma, $P = .012$; acute leukemias versus breast cancer, $P = .009$.

having had an eye exam in the past year ($P = .05$) compared with survivors who received more intensive therapy. No other differences related to the intensity of treatment were found.

DISCUSSION

This is the first study to examine the health and cancer screening behaviors of long-term cancer/HCT survivors compared with matched noncancer controls. Contrary to our hypothesis, and despite their more frequent physical exams and good access to health care, for the most part these survivors engaged in preventive health practices no more frequently than matched controls (and in some cases less frequently). These results are somewhat surprising given the “second chance at life” afforded these survivors and their increased risk of late effects and second cancers because of the high-dose therapy associated with HCT.

With regard to health behaviors, the smoking and alcohol consumption rates reported by the survivors in

our study were similar to those reported previously by other cancer survivors [6]. The physical activity rate reported by survivors in this study (34%) was lower than the rates reported in some studies of cancer survivors (42%–83%) [5,6,8], although population-based studies have found that only 22% of cancer survivors are physically active [7], and some 75% of survivors are not complying with physical activity recommendations [8]. Given that physical activity rates and body weight are increasingly recognized as important risk factors for poorer outcomes in cancer survivors [13], attention to this area is merited. The secondary cancer screening rates in our study were similar to those in other studies of cancer survivors; however, in contrast to other studies [8,14], we did not find these rates to be better than those in noncancer controls. This may result from the fact that the survivors and controls in this study were primarily Caucasian, well educated, and fairly affluent.

We found that autologous HCT survivors are more likely than allogeneic HCT survivors to report breast and cervical cancer screenings in the past year, who were more likely to have received a skin exam.

Table 6. Survivor Health Examinations and Cancer Screening Behaviors by Disease Group and Type of Transplant (n = 662)

	Acute leukemias, n (%)	CML, n (%)	Lymphoma, n (%)	Breast cancer, n (%)	P Value	Allogeneic HCT, n (%)	Autologous HCT, n (%)	P Value
Physical exam	209 (89)	116 (92)	111 (86)	146 (97)	.006	240 (92)	342 (91)	.519
Eye exam	156 (67)	92 (73)	84 (65)	96 (64)	.409	183 (70)	245 (65)	.161
Skin exam	111 (47)	72 (58)	48 (38)	71 (47)	.017	141 (54)	161 (43)	.004
Colorectal cancer screening (aged 50+ years only)	37 (42)	23 (43)	32 (44)	51 (57)	.144	38 (43)	105 (49)	.329
Breast cancer screening (women aged 50-65 years)	27 (71)	17 (61)	20 (77)	68 (85)	.051*	28 (61)	104 (83)	.003
Pap smear (women)	81 (63)	50 (74)	47 (81)	114 (77)	.027†	94 (66)	198 (77)	.021
Prostate cancer screening (men aged 50+ years)	23 (49)	18 (78)	31 (72)	NA	.020	22 (54)	50 (69)	.093
All suggested screenings	32 (14)	28 (22)	18 (14)	27 (18)	.157	46 (18)	59 (16)	.499

NA, indicates not applicable; CML, chronic myelogenous leukemia.

We acknowledge that mammograms may be indicated for some HCT survivors under the age of 50 years; however, for the purpose of comparison with controls, we report only on those women aged 50-65 years who reported breast cancer screenings.

*Pairwise comparisons: breast cancer versus acute leukemias, $P = .074$; breast cancer versus CML, $P = .007$; breast cancer versus lymphoma, $P = .737$.

†Pairwise comparisons: breast cancer versus acute leukemias, $P = .012$; breast cancer versus CML, $P = .577$; breast cancer versus lymphoma, $P = .531$.

It is possible that allogeneic and autologous HCT survivors have different expectations for posttransplantation outcomes. Allogeneic HCT survivors may expect the treatment to be curative and the risk of second cancers to be small, whereas autologous HCT survivors, aware that the risk of recurrence is fairly high, may be more likely to screen for second cancers. The greater frequency of skin examinations reported by allogeneic HCT survivors could reflect their vigilance for signs of GVHD rather than a focus on skin cancer. Alarming, although the reported influenza vaccination rate was greater in the HCT survivors than in the controls, it should have been higher than 60% given these patients' "at risk" status [15].

Our finding of poorer than expected and desired health behaviors in HCT survivors may reflect a lack of education and/or understanding about survivorship issues, such as the need for continued surveillance for second cancers and engagement in healthy behaviors to reduce late effects, decrease the risk of other diseases, and improve quality of life. Previous studies have noted that nearly half of cancer survivors are unaware of their increased risk for second cancers [8]. Of course, perceived risk alone is not sufficient to induce behavioral change. Perceived susceptibility, control, and self-efficacy—constructs described in the Health Belief Model [16] and other models of behavioral change—may be necessary as well. Future studies should examine the perceptions of risk, as well as causal attributions and beliefs regarding the effectiveness of screenings and health behaviors in attenuating these risks.

Given that the survivors in our sample were more likely than controls to have undergone a physical exam, but generally no more likely to have engaged in healthy behaviors or received cancer screenings and influenza vaccinations, it is possible that the survivors' physicians also were unaware of their need for a different pattern of care. Studies suggest that as few as 20% of providers talk with cancer survivors about health behaviors [6], and that only 10% of survivors report that their physicians talk to them about smoking, exercise, and diet [17]. Gaps in preventive care may be related to type of provider. Primary care physicians provide health care for an increasing number of adult long-term survivors of HCT [3], and although guidelines exist for recommended screening and preventive practices for long-term HCT survivors [18,19], some primary care providers (PCPs) may not be aware of these. There is evidence that PCPs are less likely to screen their patients for second cancers than oncologists, who may be less likely to engage in non-cancer-related preventive services [20,21]. Survivors who see both types of providers tend to receive more services [21]. The Institute of Medicine's report on cancer survivorship cites many shortfalls in the posttreatment health and preventive care of cancer survivors high-

lighted by our results, and recommends the use of transition care plans to help address these issues [22]. However, one could argue that health behavior recommendations should be incorporated into a patient's care from the moment of diagnosis, with the goal of maximizing physical stamina and general health to both withstand treatment and maintain maximal health through survivorship. In fact, there may be a window of opportunity around the time of diagnosis (within 6 months) when health issues are most salient for patients and the motivation to live and live well is at its peak [23].

Our study has several limitations. The cross-sectional design and unknown prediagnosis behaviors make it impossible to determine whether health practices changed as a result of the diagnosis and treatment. However, the similarities between the reported behaviors of survivors and matched controls suggest that changes in health behaviors did not occur as a result of the cancer/HCT. Unfortunately, there were no standardized measures of health and screening behaviors at the time of the study, and so we developed our own, making cross-study comparisons difficult. A particular limitation of our measure is that it asked about health screening behaviors in the past year, even though some recommendations are for less than yearly exams (eg, Pap smears are recommended every 1-3 years). Guidelines for recommended health behaviors have undergone recent changes that may affect the applicability of these time frames to the health behaviors of current and future long-term HCT survivors. The development of standardized questionnaires for health behaviors and screenings (including dietary behaviors, which we did not address) would be an asset to this area of study, albeit challenging to accomplish as recommendations change over time.

Additional limitations of the study are that our sample was predominantly Caucasian (which reflects the ethnic makeup of the BMT patient population as a whole) and that Caucasians were more likely to participate in the study than non-Caucasians, which limits the generalizability of the results to non-Caucasians. These 2 issues are particularly important, because other studies have shown differences in health behaviors related to race/ethnicity. Although we used randomization of eligible survivors in an attempt to obtain the most representative sample possible, we did find other differences between participants and nonparticipants. Compared with all nonparticipants, the participants were slightly older, more likely to be female, less likely to have had lymphoma, and more likely to have had breast cancer, more likely to be in early disease (than intermediate or advanced) before pre-HCT treatment, and more likely to have received an autologous transplant. But, none of these differences were found when comparing participants to those who actively refused study participation, except

that participants were more likely to have received an autologous transplant. Further studies are needed to address these potential shortcomings.

Taken as a whole, our findings indicate that the experience of cancer along with the intense HCT treatment apparently does not result in significantly improved health behaviors and screening practices after treatment. Although many of the health behaviors and screening rates reported in the HCT survivors were comparable to those reported by cancer survivors in other studies, there remains considerable room for improvement. Health promotion and lifestyle interventions to optimize health during and after cancer treatment are necessary to effectively manage, treat, and prevent comorbidities. Education of providers, survivors, and family caregivers is needed. To maximize the effectiveness of this teaching, it should begin shortly after diagnosis.

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